FEDERAL AVIATION ADMINISTRATION

DRAFT

AIRE & SESAR JOINT UNDERTAKING: GREEN FLIGHT DATA GUIDANCE

APPLICABLE FOR 2009 PROGRAM

OCEANIC-TAILORED ARRIVAL

DEMONSTRATIONS

THE QUANTIFICATION OF FUEL BURN REDUCTION AND ENVIRONMENTAL BENEFITS

Coordinated by
FAA Office of Environment & Energy

With
Federal Aviation Administration - Air Traffic Organization, Boeing, Calibre Systems, CSSI, Johns Hopkins APL, MCR LLC, Mosaic ATM, MITRE CASSD, Veracity Engineering, and VOLPE

Version 1

WASHINGTON, DC 20591

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AIRE METRICS

APPLICABLE TO FY09 MEASUREMENTS TO QUANTIFY FUEL BURN REDUCTIONS AND ENVIRONMENTAL BENEFITS

1.0 PURPOSE OF DOCUMENT

This AIRE metrics white paper is part of a set of guidance documents to support of the Federal Aviation Administration's (FAA) Atlantic Interoperability Initiative to Reduce Emissions (AIRE) Program. It addresses the "GREEN Flight" test coordination with our European (SESAR Joint Undertaking) colleagues on committed flight demonstrations in 2009. The purpose of this document is to briefly outline proposed environmental and operational performance benefits metrics, coordinate resulting test data acquisition/exchange and presents background on the comprehensive environmental modeling analysis that will be exercised. These guidelines and data format recommendations presented serves as a preliminary framework to support of the AIRE 2009 "GREEN Flight" Proof of Concept Demonstration discussions and planning.

This document provides the FAA AIRE systems team and SESAR Joint Undertaking members, comprised of ANSPs, and airline pilots and AOC operators an outline of metric issues to coordinate, proposed acquisition process for recording performance and environmental data associated with the GREEN test flights. This is Version 1 that provides background on the long term AIRE Metric Plan in support of the continuing system/procedures demonstrations. This plan will be reviewed by the AIRE Team and participants in order to establish an agreement as to the execution of: 1) establishing a baseline of data, 2) demonstration of "limited dry-run" the week (before the actual demonstration), and 3) the AIRE GREEN Flight test demonstrations.

2.0 AIRE BACKGROUND

Since the 2007-08 spiking of petroleum fuel prices and its impact on transportation, many aviation stakeholders have been in continuous pursuit of comprehensive energy efficiency for near- and long-term sustainability of aviation. This is an extreme challenge for an industry that continues to be at forefront technology with a tremendous passenger/mile safety and effectiveness record – 841,672 million passenger miles flown in 2007. However, constrained by uncertain fuel cost and supply, and further threatened by the added attention of Climate change response and its potential of added carbon emission trading expenses[1], many from system manufacturers of aircraft, engines[2], and subsystems to airline and airport operators as well as national aviation navigation service providers (ANSP - the authorities of air traffic control), have been committed to identifying and

[1] Ponticel, Partrick, "Airlines to come under EU greenhouse-gas regulations," Aerospace engineering & manufacturing, SAE International magazine, August 2008, page 18-19,

[2] Costlow, Terry, "Flying into cleaner skies – Engine efficiency save money, trim pollutants," Aerospace engineering & manufacturing, SAE International magazine, August 2008, page 30-33.

instituting solutions for fuel efficiency with equally effective environmental performance that reduces noise, carbon emissions (CO2), Nitric Oxides (NOx), and particulates matter (PM).

As demand for aviation services are expected to grow, the environment must be protected by assuring that our aeronautics enterprise achieves greater efficiency and energy availability. Therefore, FAA goals are aimed to reduce significant environmental impacts associated with noise, emissions, and global climate impact in absolute terms. This is happening against a backdrop of emission reductions from sources other than aviation, and as well, the rising values we place on environmental quality. If not successfully addressed, environmental issues may significantly constrain air transportation growth in the 21st century.

The Federal Aviation Administration (FAA) and the European Commission (EC) recognize the value of cooperation to achieve global aviation objectives and meet the requirements of all airspace users. The EC and FAA have formed a partnership called the Atlantic Interoperability Initiative to Reduce Emissions (AIRE) to explore opportunities focusing on research, development, and accelerated implementation of environmentally-friendly air traffic standards and procedures.

ATM initiatives launched by these organizations will greatly improve air transportation safety, capacity and efficiency. With regard to environmental impacts, the US Next Generation Air Transportation System (NextGen) and the Single European Sky ATM Research (SESAR) Program, will shorten flight times, reduce fuel consumption and engine emissions, and lessen aircraft noise.

This metric white paper supports the preliminary technical planning discussion for the launch of US-EC AIRE activities. This paper aims to frame the collaborative exchange of system and performance data and information needed to execute a successful flight demonstration that identified the environmental mitigation potential of Arrival, Oceanic and Surface ATM systems involved.

3.0 ENVIRONMENTAL METRICS & POTENTIAL BENEFITS

Since the launch of the US AIRE Program in 2008, Environmental benefits have been analyzed separately for each flight segment demonstrated since each domain is operationally unique by system technologies and procedures. Yet, for each operational domain – surface, oceanic and arrival, the quantification of the environmental footprint has discretely focused on the determination of fuel saving as the primary environmental metric. For 2009 demonstrations, FAA plans to continue to follow a systematic approach to gage environmental mitigation for three phases of flight – surface, oceanic and arrival, however exploring more seamless and efficient operations in a single flight execution. The environmental mitigation occurring for each domain will be assessed relative to a selected baseline condition appropriate for that enhanced technology. A summary of the three AIRE demonstration technologies and preliminary assessment metrics (operational and environmental) are presented in Table 1.

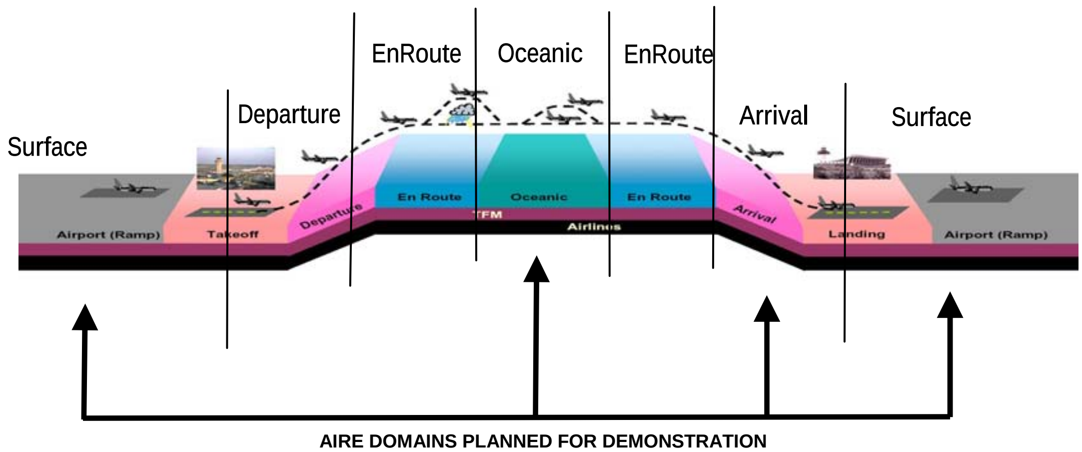


Figure 1. Aviation Operational Domains

Table 1. outlines each of the AIRE domains proposed demonstration technology/ systems, the defined measurement source for relating the operational and corresponding environmental metrics, and relative operational baseline (current operational capability level). New technologies and procedures, when applied to a currently equipped aircraft under unimpeded traffic conditions, has indicated a potential fuel savings as high as 4%[3]. With this new estimated margin of fuel savings relative to AIRE's cumulative 2008 findings of ~1.5% fuel saving, there is an estimated doubling of the 2008 AIRE gains available in fuel saving still to be achieved. Each pound of aviation fuel not consumed equals over 3 fewer pounds of CO2 emissions. AIRE flight trials and demonstrations scheduled for each domain will demonstrate and quantify these benefits, and validate the estimated potential for fuel saving and emissions reductions.

Domain - Demonstration Technology	Operational Metric Fuel - gals (surrogate)	Environmental Metric - CO_2- lbs	Baseline (rel. ops levels)
Surface	Fuel burn measured (Taxi time)	Carbon Dioxide derived from fuel measured or Derived using ICAO Engine Performance Data	JFK operations- ASDE-X off Vs ASDE-X on
Oceanic	Fuel burn measured (Greater circle route)	Carbon Dioxide derived from fuel measured (compared against AEDT model)	Pre-Green Operations Vs Green Operations
Arrival	Fuel burn measured (arrival trajectory)	Carbon Dioxide derived from fuel measured (compared against AEDT model)	Pre-TA/CDA Operations Vs TA/CDA Operations

Table 2. Technology, Ops Metric, Environmental Metric and Baselines

[3] www.airways.co.nz/ASPIRE/index.asp

Note: grayed area must be defined with our EU partners.

4.0 QUANTIFICATION OF ENVIRONMENTAL BENEFITS

In 2006 for the first time in history, fuel became the single largest component of U.S. airline operating cost. With the potential cost of a barrel of oil oscillating at $100 a barrel, the focus on fuel conservation continues to be the primary concern and focus of Research & Development, not only because of environment sustainability, but with regard to energy stability and economic security. Compounded with the World recognition of Climate change and the environmental need to mitigate CO2 emissions, the AIRE program aims to address these aviation concerns and demonstrate viable, enhanced ATC operations performance with environmental mitigation alternative solutions.

For the 2008 AIRE demonstrations, environmental benefits were analyzed for Oceanic and Arrivals domains and identified valued fuel savings and significant reductions in emissions. This activity will continue for current proposed AIRE demonstrations with the primary environmental metric designated as **jet fuel burned/saved**. For the surface, oceanic and arrival operations, the quantification of fuel use provides a directly relationship to the advances in ATC systems and/or procedures being applied that enhance the operational efficiency. Important for AIRE is that the ATC efficiency improvements that offers fuel saving also translate into environmental savings (or mitigation) in the form of reduced engine emissions, such as CO2 - a primary Green House Gas, and potentially community noise. Aircraft noise reduction is an equally important benefit for surrounding airport communities in support of new systems and procedures. A secondary effect indentified has been the reduction in flight time (or potential early arrival) that has an economic value for certain operations, i.e. postal and freight.

DATA & ROLES

Participants Role: Under AIRE collaboration, data and information is supplied and shared among participant from several operational entities that support the airline flight operations-Aviation Navigation Service Providers (ANSP), Airline Operations Center (AOC), and the airline pilots. During the 2008 demonstrations, several sets of data for the demonstration flights were recorded and shared by the ANSP services, the AOC and/or recorded on-board the aircraft by the flight crews. Such information was either manually recorded or was automatically stored by an existing support system, i.e. Ocean21/ATOP, Air Europa AOC system, and made available to the analysis team after extraction. Given the success of that data acquisition process, the proposed 2009 AIRE demonstrations will continue in the same manner. However,, the AIRE team would like to propose that AIRE partner airlines explore whether CFDR/FOQA stored data on equipped candidate aircraft could be made available to allow for more comprehensive flight analyses. As discussed in Section 6.0 on Other Supporting Data Sources, CFDR/FOQA maybe an alternative means for measuring flight operational metrics to gage performance changes. The specific data metrics/parameters requested for a data recording and extraction are those highlighted in yellow at a minimum. The following outlines the 3 methods potentially available for meeting the data acquisition requirements for 2009 AIRE demonstrations. At minimum the Pilot log sheet and AOC System data and information has successfully satisfied testing goals. Supplemental availability of CFDR/FOQA data would increase the fidelity of the data and validate other measures.

Methods of Data Acquisition:

- Pilot/crew Log sheet: During flights, pilot/crew read aircraft instrument panel and manually transcribe fuel measurements on a data log; and/or
- CFDR/FOQA system: For aircraft equipped, airlines typically operate an onboard automated Cockpit Flight Data Recorder (CFDR) system and airlines routinely perform flight data dumps to their Flight Operations Quality Assurance (FOQA) offices. As such, this process offers a potential test data extraction opportunity for the requested aircraft operational metrics/parameters.; and/or
- AOC System: Concurrent with flights, Airline Operations Center (AOC) compile flight plans, intent, and actual operations tracking data, per AOC reporting system.

So in preparation for flight demonstrations, US AIRE Test Teams will schedule technical meetings with the SESAR Joint Undertaking Team, participating airlines and air traffic service providers to discuss the sharing of data and information needed to assess the environmental and operational benefits. The three phases over which data will be acquired, shared and explored are outlined as follows:

I. Recording of accurate flight plan and intent data for pre-AIRE demonstration flights – for the one month prior to scheduled AIRE demonstrations *(proposed start ~1 May)*

II. Recording of accurate flight plan and intent data for AIRE demonstration flights – for the two month of AIRE demonstrations *(proposed start ~2 June)*

III. Identification of current and future flight planning capabilities and airline priorities and constraints – over the course of the program yet before Sept 2009. *(proposed start ~ July)*

I. PRE-AIRE DEMONSTRATION FLIGHT DATA

One (1) month prior to the scheduled AIRE flight demonstration(s), the ANSP(s) and the airline participant will the coordinate, record, compile, and report on flight data and ATM/AOC information for the same type candidate aircraft expected in the AIRE demonstrations. This activity will serve to: 1) establish a baseline set of data for comparison of flight performance against AIRE flights and 2) perform a dry run of the data and information coordination, acquisition and analysis before more comprehensive test begins. The AIRE team proposes that this data acquisition occur as frequently as the flight operations for the similar AIRE candidate aircraft over a 30-day period prior to AIRE flights. This baseline data is to be exchanged, analyzed and assessed prior to the AIRE demonstrations flights, if possible, to sort out any technical problems and retained for latter comparison with AIRE test flights.

Depending on the method of data acquisition identified in collaborative planning, the specific data metrics (parameters) to be recorded will apply the methods and formats outlined in: Appendix V: Flight Crew Data Log, Appendix VI: Flight Operations Quality Assurance, and Appendix VII: Flight Plan & Intent Data. This initial 30-day period of flight measurements will serve as an operational proofing flight operations and trial of data coordination, acquisition, and analysis.

II. AIRE DEMONSTRATION FLIGHT TEST DATA

For the 2-months of scheduled AIRE flight demonstration(s), the ANSP(s) and the airline participant will the coordinate, record, compile and report on flight data and ATM/AOC information for the same AIRE candidate aircraft assessed for the baseline flights. As a precaution, it is preferred that this data is to be exchanged and assessed after the every 2-weeks to evaluate on-going test progress and correct technical problems that may arrive.

Similarly, depending on the method of data acquisition identified in collaborative planning, the specific data metrics (parameters) to be recorded will apply the methods and formats outlined in: Appendix V: Flight Crew Data Log, Appendix VI: Flight Operations Quality Assurance, and Appendix VII: Flight Plan & Intent Data. This initial 30-day period of flight measurements will serve as an operational proofing flight operations and trial of data coordination, acquisition, and analysis.

III. AIRLINE PLANNING SYSTEM - CAPABILITIES/PRIORITIES/CONSTRAINTS

Airline Planning System Characterization- To fully understand the key factors contributing to improved operations and environmental efficiency based on these demonstrations, it will require the identification of airline flight planning capabilities, priorities, and constraints. The 2008 AIRE demo flights did not explore the airlines' flight planning capabilities of an Airline Operations Center (AOC). So this is the next important step, in exploring ATM interactions and technical system capabilities that can lead to greater optimization. Knowledge and information on AOC system capability that generate flight plans and en route amendments will be explored to understand factors that minimize fuel burn (given the normal airline business model/cost index).

The plan is to identify and share the "gate to gate" system understanding on potential:

1) improvement factors that may be enhanced through collaboration and/or information exchange;
2) constraints that may be difficult/ expensive to alter; and
3) other related priorities/limitations that are facing the airlines today.

The design of the follow-on AIRE demonstrations and further refinement of concepts will benefit from this comprehensive exploration.

The following two aspects of flight management are addressed to guide the discussion.

- Flight Planning Capabilities: Discuss a list of factors that could affect flight planning and how these factors affect flight planning and amendments, i.e., representative winds/weather, etc.
- Strategies to counter Efficiency Losses: Compare an "ideal" trajectory (no constraints) to an actual (e.g., AIRE) trajectory and identify factors that contribute to the difference, i.e., maintain safe separation, traffic conflict, etc.

The specific exploratory questions for further technical discussion on these two aspects are in the Appendix VIII: Airline Planning System Characterization.

FUTURE BENEFITS MODELING -AEDT

In this exploration of the environmental mitigation potential under AIRE, a thorough set of environmental metrics can be derived and compared against the baseline operations. Both fuel and corresponding Carbon Dioxide (CO_2) are the primary metrics of importance as it reflects operability and environmental impact, respectively. Fuel saved will be quantified either by measures available from airline participants (i.e., flight data recorder or airline system) or derived from surrogate operational metrics. In some cases, the Federal Aviation Administration (FAA) Aviation Environmental Design Tool (AEDT) suite will be applied to facilitate the modeling of aircraft operational analyses of environmental interdependencies between noise and emissions, fuel burn, and provides for an evaluation of air quality and noise impact. The primary engine emissions metrics derived will be Carbon Dioxide (CO_2) with potential supplemental metrics that could be computed from AEDT prediction:

Nitrogen Oxides (NO_x), Carbon Monoxide (CO), Hydrocarbons (HC), Water (H_2O), Sulfur Oxides (SO_x), non-Methane Hydrocarbons (NMHC), Volatile Organic Compounds (VOC), Methane (CH_4), Particulate Matter (PM) with an aerodynamic diameter of less than or equal to 10 μm (PM10), and PM of less than or equal to 2.5 μm (PM2.5).

The potential noise metrics from AEDT computation could include:

- Day Night Average Sound Level (DNL) contours - for cumulative airport operational noise (footprint) scenario comparisons. [when the data sample for number of flights is greater than 100 for a broad airport wide impact assessment]

- A-Weighted Sound Exposure Levels (SEL) at a series of grid points - for each individual approach track noise comparisons. [preferable when the data sample for number of flights is nominally 6 or more for a single event, operational changes assessment]

Again, both fuel and corresponding Carbon Dioxide (CO_2) are the primary metrics of importance as it reflects operability and environmental impact, respectively. Fuel saved will be quantified either by measures available from airline participants (i.e., flight data recorder or airline reporting system) or derived from surrogate operational metrics as needed.

The quantification of the surrogate operational metrics, such as taxi time and flight trajectories, will be used to derive and validate the estimated potential fuel saving and corresponding emissions reductions. The specific computational approaches applied to Domain demonstrations and environmental metrics are summarized in Table 1. The version of AEDT available is AEDT 1.3.

Table1. Environmental Methods Applied by Domains for each Environmental Metrics.

Environmental Metrics	DOMAINS		
	Surface	Oceanic	Arrivals
Fuel burn	Airline Service Quality Performance (ASPQ)- fuel burn indices multiplied with taxi time	As measured by Airline participant(s) or AEDT using ATOP trajectory reports or ICAO BADA equivalent	AEDT using PDARS trajectory data

Emissions Factor (primarily CO2)	Airline Service Quality Performance (ASPQ) - emissions factor indices multiplied with taxi time	Simplified Carbon Dioxide (CO2) conversion of fuel or AEDT	Simplified Carbon Dioxide (CO2) conversion of fuel or AEDT
Noise Level	Not applicable	Not applicable	AEDT using PDARS trajectory data

5.0 ACTIVITY COORDINATION

Current AIRE/SJU planning will address formalization of activities of the AIRE "gate-to-gate" flights from Charles de Gaulle (CDG) International Airport- Paris, France to Miami (MIA) International Airport- Miami, Florida USA that are scheduled to start in June 2009.

Demonstration coordination, data acquisition, and ATM performance/benefits analyses will be discussed and coordinated between the FAA AIRE Program and SESAR Joint Undertaking Office in conjunction with the primary ATC technical system leads. Even as AIRE/SJU activities evolve towards a seamless, more efficient, gate-to-gate flight operation, each particular flight domain (or activity segment) will continue to be studied in independently to clearly define and quantify its contribution to a overall full flight. The AIRE demonstration flights are tentatively planning to enhance operations for each of the following domains/segments of operation – Surface, En route, Oceanic and Arrival. A short description of each in presented for further discussion and planning development.

SURFACE

The proposed surface enhancement activity is being planned by the SESAR Joint Undertaking. More will be technically defined upon discussions with our European counter parts.

EN ROUTE

The proposed en route enhancement activity is being planned by the SESAR Joint Undertaking. More will be technically defined upon discussions with our European counter parts.

OCEANIC

For trans-Atlantic operations from European airspace through US airspace, the AIRE participants will explore further efficiencies achievable through FAA Collaborative Oceanic Trajectory Based Operations enhancements using Ocean21 in concert with Nav Portugal's Systems.

In support of the FAA's Oceanic Trajectory-Based Operations (TBO) program, the concept uses trajectory-based operations to improve fuel efficiency and predictability by enabling operators to fly closer to their optimal (or preferred) 4D trajectories. As part of this initiative, trajectories will be evaluated at pre-departure to support system-wide planning and in-flight operations to take advantage of more current data. Much of the TBO concept relies on the FAA receiving accurate information on a flight's preferences, intent, and priorities. The Oceanic AIRE demonstrations provide an opportunity to research the current capabilities and to allow the FAA and airlines to coordinate and identify the vital common information that needs to be shared to achieve greater operational efficiency.

Previously reported application of Ocean21 real-time system has resulted in optimized enroute operations capability among ATC and airlines. This demonstration of the Ocean21 system will investigate the operational enhancements/savings and the associated environmental benefits achievable. The fundamental analyses will measure en route performance and identify changes in cruise efficiency when challenged with weather and increases in traffic. Further baseline flight information necessary for the enhancement studies will continue to be acquired to support environmental consideration.

The environmental methodology for estimating fuel use will utilize the approached developed for Ocean21 system. The Oceanic and Off-shore Metrics Processing and Analysis (OOMPA) processes the measured the oceanic flight trajectory of the aircraft from Ocean 21 system that will be used in deriving the environmental metric – fuel burn. Supplemental emission (and noise, where applicable) metrics will be utilize the Aviation Environmental Design Tool (AEDT) computer program developed by FAA-AEE based Ocean21 trajectories. The outputs of AEDT will compute projected fuel use, noise (SEL), and emissions (CO; THC; NMHC; VOC: NOx; SOx; CO2; H2O) metrics.

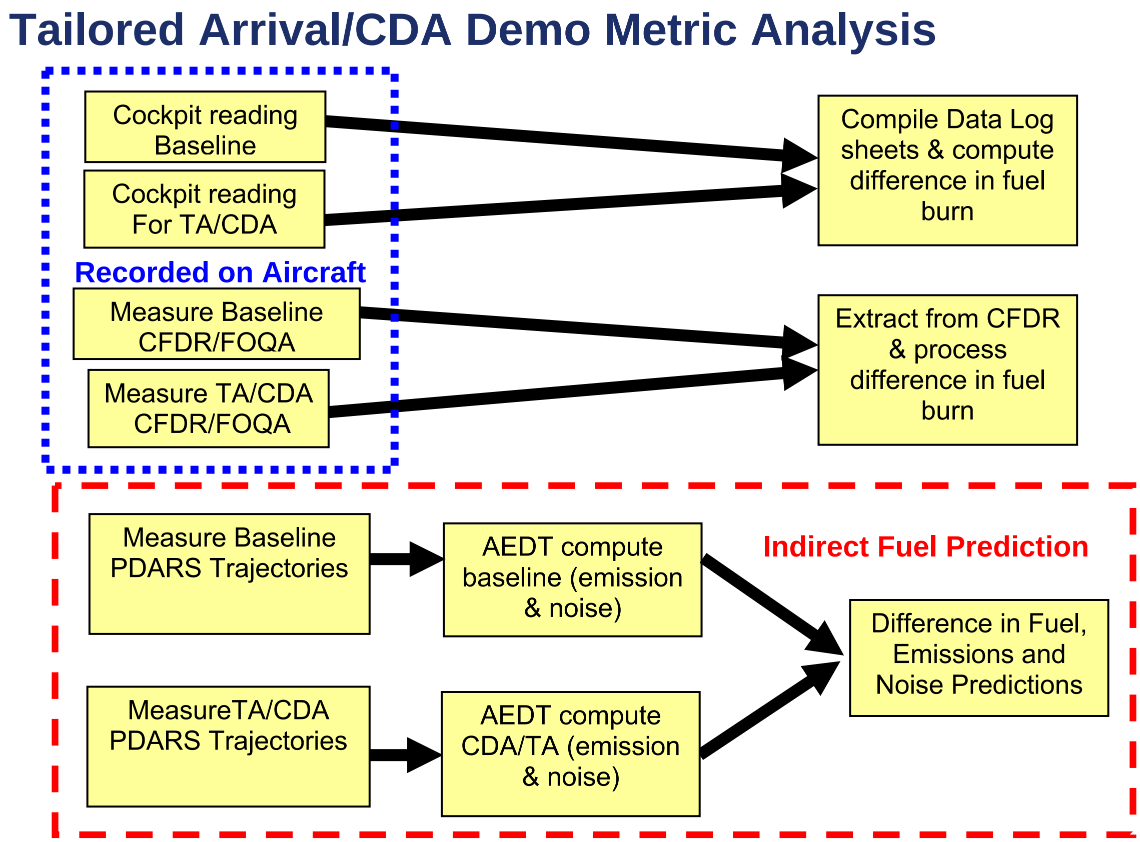
CSSI manages and support the Oceanic program office and will provide the necessary oceanic trajectory data to VOLPE for metric processing using AEDT. If CFDR/FOQA data is made available for the demonstration aircraft, VOLPE can establish a Non Disclosure Agreement (NDA) with airlines in order to process this data to supplement these analyses.

ARRIVALS

When applicable for a trans-Atlantic flight operation to Miami International Airport (MIA), a Tailored Arrival(TA) procedure demonstration, applying a Continuous Descent Arrival (CDA) technique, will be tested. TAs have been developed for trials in the initial AIRE arrivals effort in 2008. . Previously reported demonstrations of CDA and TA procedures with mixed conventional operations has identified compatibility of these environmentally beneficial use of vertically optimized profiles, its impact on ATC, and its potential aircraft performance benefits for airlines. These AIRE arrival demonstrations will focus the investigation on the operational savings and the associated environmental benefits achievable.

The fundamental analyses will measure and evaluate the actual flight trajectories implementing the CDA/TA profile, relative to conventional arrival baselines, and gauge the effects on arrival efficiency - fuel burn, and environmental effects - emissions and noise. It is preferable that Cockpit Flight Data Recorder (CFDR) information be acquired for the demonstration flights in order to measure the fuel burn for both baseline and CDA/TA flights. The environmental methodology for estimating fuel use and computing estimates of the noise and emission metrics will be utilize the Aviation Environmental Design Tool (AEDT) computer program developed by FAA-AEE. The outputs of AEDT will compute projected fuel use, noise (DNL, SEL), and emissions (CO; THC; NMHC; VOC: NOx; SOx; CO2; H2O) metrics.

The flow chart below depicts three approaches by which the primary metric – Fuel burn – is being measured and/or derived, either by: (1) logging of pilot/crew cockpit instrument readings, (2) CFDR/FOQA or (3) by AEDT modeling using PDARS radar trajectories, respectively.



6.0 SUPPORTING DATA SOURCES

Multiple data sources exist that define the operational state and position of an aircraft as well as the environment operated. The technical approach for satisfying the major AIRE objective - the validation of projected environmental improvements by flight trails and demonstrations, will require the acquisition of actual aircraft flight performance measurements and the utilization of air traffic management (ATM) operational control systems data (i.e., ATOPs, ASDE-X and PDARs) in combination with environmental analytic prediction methods found in the FAA Aviation Environmental Design Tool (AEDT). AEDT is based on theoretical and semi-empirical aircraft environmental impacts and operational flight systems data.

For AIRE, FAA intends to leverage the use actual aircraft flight performance measurements typically acquired under the existing safety program called Flight Operations Quality Assurance (FOQA). FOQA, also know as Cockpit Flight Data Recorder (CFDR) data, provides such specific flight information that can be provided by airlines FOQA offices if agreed upon. Acquisition and distribution of the ATM operational control system data will be coordinated/ provided by each of the respective Domains leads of the ATM interoperability system demonstrations – Oceanic21/ATOPs, Surface ASDE-X, and Arrival PDARs. The following section will discuss the detailed parameters to be used from standard measures and those necessary to derive predictions for a comprehensive metrics validation.

AIRCRAFT MEASUREMENT SYSTEM - CFDR/FOQA

Flight Operational Quality Assurance (FOQA) data will be requested from AIRE Program partner airlines for the flights selected representative of typical baseline operations and those proposed for enhancement under AIRE Demonstrations. Such measurements will provide actual or "gold standard" measures for the validation of the latest available prediction methods of AEDT.

In each demonstration, a series of flights will be designated for investigation and a corresponding set of CFDR/FOQA data for those airplanes will be gathered, where agreed upon, from the participating airlines for analysis and to derive the environmental and operational metrics required.

GROUND BASED RADAR NETWORK - PDARS

Over the United States, domestic airspace, the Performance Data Analysis and Reporting System (PDARS) is a fully integrated performance measurement tool designed to help the FAA manage the tracking of daily operations within air traffic control (ATC) system. The tracking and monitoring capabilities of PDARS support studies and analysis of air traffic operations. The New Large Aircraft impact analysis is also a highly visible activity within this program. PDARS data will be used to provide aircraft flight trajectory information necessary for metric development where available, such as for the domestic arrivals segments.

7.0 NEXT STEPS

Review this AIRE Metrics White paper regarding:

- pre-AIRE (1-month prior to AIRE test flights) data and information requested and determine how acquisition can be satisfied.
- AIRE demonstration data and information requested and determine how acquisition can be satisfied.
- AOC Characterization of capabilities, priorities and intent data and information requested and determine when identification discussions can be initiated.

APPENDIX I – AIRE USA PROGRAM CONTACTS

AIRE (USA) Demonstration Test Teams:

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CSSI

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APPENDIX II – AIRE-OCEANIC DEMONSTRATION PROCEDURE DOCUMENT

OCEAN-21/ATOP- COORDINATION OF REROUTE

[FAA-Boeing ATM document to be appended when available]

APPENDIX III – AIRE-TAILORED ARRIVAL (TA) DEMONSTRATION PROCEDURE DOCUMENT

TAILORED ARRIVAL PROCEDURE

[FAA- Boeing TA document to be appended when available]

APPENDIX IV- AIRE EC: DEPARTURE-ENROUTE SEGMENT

CRUISE CLIMB PROCEDURE

[Air France document to be appended when available]

APPENDIX V- FLIGHT CREW DATA LOG

DATA REPORTING FORMAT

This proposed flight crew data log and format was successfully used in the 2008 AIRE Oceanic Demonstration flight by the participating airline flight crews. It is the most important element of the flight programs since it tracks our primary metric – fuel use and any major changes in re route If there are conflicts in indentifying the requested information, please contact the US AIRE Program manager to discuss and coordinate the appropriate log format adjustments needed to report test data.

DEMO FLIGHT CREW DATA LOG *Sample template*

FLT:	REG:
FLT PLAN REF:	Date: June , 2009

TAKE-OFF DATA *(record to the 10th Kgs)*
BLOCK FUEL:
ZFM:
T/O FUEL:
T/O MASS:

POSITION		FL	FUEL
Lat	Long	Flt Level	Remaining
GATE			
CLEARED TO T/O			
N	15W		
N	20W		
N	30W		
N	40W		
N	W		
N	W		
N	W		
TOP OF DESCENT			
Waypoint			
LANDING			
GATE			
FUEL USED – 0.Kgs *(record to the 10th Kgs)*			

FLIGHT PLAN CHANGES							
Position		Latitude		Flight Level		Mach Number	
Lat	Long	OLD	NEW	OLD	NEW	OLD	NEW
N	W						
N	W						
N	W						
N	W						
N	W						
N	W						

COMMENT
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Note 1: Please fax sheet to:
or email to: *[member coordinating data acquisition]*
Note 2:

2 of 2 pages

The following is a sample Flight Operations Quality Assurance (FOQA) parameters list. Items highlighted in yellow are critical parameters required for environmental modeling analyses.

Sample FOQA list of parameters recorded by Cockpit Flight Data Recorded (CFDR)

Flight Record
Fleet
P51: average N1 over all engines from start of event
P51: average N1 left inboard engine from start of event
P51: average N1 left outboard engine from start of event
P51: average N1 right inboard engine from start of event
P51: average N1 right outboard engine from start of event
P51: average burner pressure P3 over all engines from start of event (psia)
P51: average P3 left inboard engine from start of event
P51: average P3 left outboard engine from start of event
P51: average P3 right inboard engine from start of event
P51: average P3 right outboard engine from start of event
P51: average total fuel flow all engines from start of event
P51: average fuel flow left inboard engine from start of event
P51: average fuel flow left outboard engine from start of event
P51: average fuel flow right inboard engine from start of event
P51: average fuel flow right outboard engine from start of event
P51: mean true airspeed (TAS) from start of event (sample interval)
P51: mean groundspeed (GS) from start of event (sample interval)
P51: mean vertical speed (inertial) from start of event (sample interval)
P51: mean machnumber from start of event (sample interval)
P51: average atmospheric pressure (ambient, undisturbed air, sample interval, hPa)
P51: dynamic pressure (ambient, undisturbed air, sample interval, hPa)
P51: mean lateral acceleration (sample interval, g)
P51: max. lateral acceleration (sample interval, g)
P51: mean longitudinal acceleration (sample interval, g)
P51: max. longitudinal acceleration (sample interval, g)
P51: mean normal load factor (sample interval)
P51: max. normal load factor (sample interval)
P51: mean vertical acceleration (sample interval, g)
P51: max. vertical acceleration (sample interval, g)
P51: average air temperature (ambient, undisturbed air, degrees celsius)
P51: atmospheric pressure (air pressure dynamic, lbs/ft^2, start of event)
P51: atmospheric pressure (air pressure total, hPa, start of event)
P51: atmospheric pressure (air pressure total, lbs/ft^2, start of event)
P51: Air Temperature (total) at Start of Event
P51: Air Temperature (total) at Start of Event (probe 2)
P51: Headwind at Start of Event
P51: Crosswind at Start of Event
P51: wind direction (true) start of event
P51: wind speed start of event
P51: air density (total, start of event)
P51: EGT Average at Start of Event
P51: EGT: left inboard engine at start of event
P51: EGT: left outboard engine at start of event
P51: EGT: right inboard engine at start of event
P51: EGT: right outboard engine at start of event
P51: EPR: average, percent of maximum at start of event
P51: thrust: percent of maximum at start of event
P51: thrust lever angle (left inboard engine, start of event)

P51: thrust lever angle (left outboard engine, start of event)
P51: thrust lever angle (right inboard engine, start of event)
P51: thrust lever angle (right outboard engine, start of event)
P51: thrust reversers deployed at start of event (true if < 0.5)
P51: EMS thrust per engine (average over all engines at start of event)
P51: EMS thrust per engine (enhanced, average over all engines at start of event)
P51: N1: average (all engines, percent of maximum) at start of event
P51: N1: left inboard engine at start of event
P51: N1: left outboard engine at start of event
P51: N1: right inboard engine at start of event
P51: N1: right outboard engine at start of event
P51: average N2 over all engines at start of event
P51: average N3 over all engines at start of event
P51: Flap Position at Start of Event
P51: Slat Position at Start of Event
P51: Elevator Position at Start of Event
P51: Horizontal Stabilizer Position at Start of Event
P51: Yaw Trim Position at Start of Event
P51: Spoiler Position Average (left)
P51: Spoiler Position Average (right)
P51: Spoiler Position Average (left and right)
P51: Pressure Altitude at Start of Event
P51: GPS pressure altitude at start of event (best available)
P51: Density Altitude at Start of Event
P51: Radio Height at Start of Event
P51: Height Above Takeoff (best estimate) at Start of Event
P51: Height Above Touchdown (best estimate) at Start of Event
P51: calibrated airspeed (CAS) at Start of Event
P51: Airspeed (true) at Start of Event
P51: Mach Number at Start of Event
P51: speed of sound at start of event (ft/s)
P51: speed of sound at start of event (knots)
P51: Pitch Attitude (Captain's or only) at Start of Event
P51: rate of change of pitch rate at start of event
P51: Roll Attitude (Captain's or only) at Start of Event
P51: rate of change of roll rate at start of event
P51: Heading (magnetic) at Start of Event
P51: yaw / drift angle
P51: rate of change of yaw rate at start of event
P51: flight path angle (inertial) start of event
P51: lateral acceleration (start of event, g)
P51: longitudinal acceleration (start of event, g)
P51: normal load factor (start of event)
P51: vertical acceleration (start of event, g)
P51: landing gear down flag (1 = down)
P51: Average Brake Temperature at start of event
P51: Latitude at Start of Event (best available)
P51: Longitude at Start of Event (best available)
P51: Ground Track Distance from start of takeoff to Start of Event (nmi)
P51: GMT at Start of Event
P51: Time from start (first phase of flight) to Start of Event (sec)
P51: Gross Weight (lbs) at Start of Event
P51: CG position at start of event
P51: drag at start of event (clean configuration)
P51: lift at start of event

Missing Parameters from this list that have Emissions impacts are the following in order of importance:

- T3 (this is not EGT)

- P2 (need to get clarification from airline to determine where in the engine this data is from)
- T2 (need to get clarification from airline to determine where in the engine this data is from)
- Humidity

Emissions Notes: CO_2 can be easily derived from fuel burn. For other pollutants like NOx, HC, and CO, you would need at least fuel flow, duration of segment (or event), atmospheric conditions (T, P, H), and Mach number to model these using Boeing Fuel Flow Method 2.

APPENDIX VII- FLIGHT PLAN & INTENT DATA

The following is a description of the information requested. This may be modified based on the discussions with the airlines regarding their capabilities, priorities, and intent.

a. Accurate information for "optimal" and "planned" flight plans
    - This should include either: time, fix names, or lat/long fixes for when the participating aircraft will request a speed or altitude change. If available, include additional fixes for top of climbs and bottom of descents.
    - The possibility of using additional elements of ICAO flight plan that will provide intent information in the AIRE demo.
    - Pro-active reassessment of the flight plan that result in the filing of updated plans as soon as feasible, when appropriate

b. Prior to departure, the airline files the "optimal" flight plan. This is the route, altitude, and speed that the airline determines to be the ideal trajectory for this flight. This flight plan would not need to satisfy constraints imposed by ANSPs (e.g., boundary crossing fixes).

c. Prior to departure, the airline files the "planned" flight plan. This is the route, altitude, and speed profile that the airline has coordinated with the ANSPs and expects to fly assuming the information they have at the time is accurate.

d. Once the flight departs, the airline continues to reassess the flight plans and update ATC on changes. Since the airline will not be able to update the flight plan in the ATC system, these updates should be via flight plan change requests, using the reroute message. The request should include all future fixes, altitude, and speed changes.

SAMPLE OF DATA REPORTED

The following sample output and data format of flight planning and intent data was reported in the 2008 AIRE Oceanic Demonstration flight by participating airline Air Europa's AOC. It represents a suitable set of data sufficient to aid in the benefits analysis.

```
CFP INPUT MESSAGE DATE TIME REF 261312
START OF CFP REF : FPCEP  -  AEAPTPT 01 MAD  HAV
```

SAMPLE OF DATA FOR REPORTING

```
     ETOPS ETPS CRITICAL FUEL AND RULE TIME/DIST. VALIDATED 180 MINS
AEA051 /26  MAD-HAV  -OP PLAN     1312/26MAY08
REG EC-JZL  A330-202 CF6-80E1A4   MTOM 233000 MZFM 170000 MLM 182000
RC FPCEP    ETD MAD261325 ETA HAV2320 SCH  9.55

CAPT ................   FO .................    SN .................
COMPANY MESSAGES

PLAN DE VUELO ACTUALIZADO CON UPDATE WX Y AZFM
PVC CALCULADO CON 210 PAX POR 110 KGS
INCLUIDOS 600 KGS DE CARGA

MAN FLIGHT LEVELS USED

ROUTE 1
FL290/DIRMA 350/GUNTI 360/3630N 380/3160N 400
LEMD BARD1E BARDI UM191 DIRMA UZ23 GUNTI DCT ETP2 DCT 3820N DCT 3630N
DCT E.ENT DCT 3440N DCT ETP3 DCT 3250N DCT E.EXT DCT 3160N DCT FIR
DCT PRUIT A637 MILLE DCT GUAVA DCT ZQA DCT PLUMA R628 TANIA NANKU2
MUHA
TOM 203834 KG ZFM- 146934 KG PL  23929 KG LM 155915 KG DOM 123005

FLIGHT PLAN SPEEDS BASED ON LRC

FUEL CONSUMPTION -**FACTOR DEG PERFORMANCE  0.0 PCTN **
MASS CHANGE P 5000 KGS FP  988 KGS TM 09.08

FUEL PLAN
GROUND DIST 4188NM  AV WC  P3
TRIP             47919 09.09 .....    MIN DIV 4119
CONTINGENCY       2396  0.27 .....    5PC
ALTERNATE         2230  0.25 .....    MUVR
FINAL RESERVE     1889  0.30 .....
ADD FUEL             0  0.00 .....
MIN T/O FUEL     54434 10.31 .....
TAXY               500       .....
EXTRA             2466  0.39 .....    EXCESS
TOTAL FUEL       57400 11.10 .....    FUEL LOADED
ZERO FIVE SEVN FOUR ZERO ZERO  KGS

DIVERSIONS MUVR  FL110 M006  108NM  2230 KGS TM 00.20
```

Highly Recommended Fuel planning data & information to report

```
START OF ICAO FLIGHT PLAN

(FPL-AEA051-IS
-A332/H-SGHIPRWXYJ/SD
-LEMD1325
-N0454F290 DCT BARDI UM191 DIRMA/N0469F350 UZ23 GUNTI/M081F360
 DCT 38N020W 36N030W/M081F380 DCT 34N040W 32N050W
 31N060W/N0463F400 DCT PRUIT/N0463F400 A637 MILLE DCT GUAVA DCT
 ZQA DCT PLUMA R628 TANIA DCT
-MUHA0909 MUVR
-EET/LPPC0025 LPPO0119 KZNY0355 TXKF0624 KZNY0659 KZMA0753
 MUFH0836 20W0151 30W0253 40W0355 50W0501 60W0612
 REG/ECJZL SEL/LSDR RALT/LEMD LPPT LPAZ TXKF MYNN MUHA
 DAT/SV COM/CPDLC ATN)

END OF ICAO FLIGHT PLAN
```

Typical Filed Flight Plan Info

ROUTE PLANNING GUIDE

Highly Recommended route planning data to report. Serve as baseline.

WP	IDENT	COORDINATES	WIND	ELAP TIME	PFL	MACH	GS	WC	TEMP	TO DEST
	LEMD	N40283W003336								4188
	NVS	N40221W004150	230/014	0.07	CLB			M012	M13	4148
	TOC	N40286W005146	280/030	0.16	290		323	M023	M43	4102
	BARDI	N40350W006182	280/030	0.23	290	772	427	M027	M46	4053
	RIVRO	N40374W006434	300/036	0.25	290	774	421	M034	M45	4034
	ETP1	N40380W006520	300/039	0.26	290	773	420	M035	M45	4027
	VIS	N40434W007532	300/039	0.33	290	773	420	M035	M45	3980
	DIRMA	N40511W009301	310/037	0.43	290	770	421	M032	M45	3906
	VEDEL	N39515W012402	340/055	1.03	350	810	468	M001	M52	3749
	PIGOR	N39280W013493	340/076	1.11	350	810	474	P005	M52	3691
	GUNTI	N39000W015000	340/076	1.19	350	810	473	P004	M52	3629
	ETP2	N38316W017310	340/074	1.35	360	810	455	M012	M54	3507
	3820N	N38000W020000	340/074	1.51	360	810	455	M012	M54	3385
	3630N	N36000W030000	010/032	2.53	360	810	476	P009	M54	2890
	E.ENT	N35223W033405	070/027	3.16	380	810	491	P028	M57	2706
	3440N	N34000W040000	070/027	3.55	380	810	491	P028	M57	2383
	ETP3	N33079W044540	010/018	4.27	380	810	471	P006	M56	2131
	3250N	N32000W050000	010/018	5.01	380	810	471	P006	M56	1863
	E.EXT	N31268W056268	230/031	5.47	380	810	439	M026	M56	1531
	3160N	N31000W060000	230/031	6.12	380	810	439	M026	M56	1346
	FIR	N30432W061443	200/027	6.24	400	810	446	M017	M58	1254
	PRUIT	N29486W066335	200/027	6.59	400	810	446	M017	M58	998
	NUTRE	N28472W068339	020/028	7.14	400	810	486	P022	M56	876
	ETP4	N27495W070228	020/036	7.27	400	810	491	P027	M57	764
	NOOGY	N27454W070297	020/036	7.28	400	810	491	P027	M57	757
	TOCCO	N26489W072111	020/032	7.41	400	810	489	P026	M58	650
	MILLE	N25556W073435	030/030	7.53	400	810	490	P027	M58	552
	GUAVA	N25084W076546	030/035	8.15	400	810	489	P026	M58	373
	ZQA	N25024W077282	030/038	8.19	400	810	488	P025	M57	342
	PLUMA	N24443W078058	030/037	8.24	400	807	491	P029	M57	303
	MENDL	N24272W078407	020/035	8.28	400	807	488	P026	M57	267
	ZOLLA	N24146W079061	020/034	8.32	400	807	485	P023	M57	241
	TANIA	N24018W079317	010/033	8.35	400	807	483	P021	M57	214
	FIR	N24000W079386	010/033	8.36	400	807	475	P013	M58	207
	ETP5	N23559W079542	010/033	8.38	400	807	475	P013	M58	192
	TOD	N23430W080424	010/033	8.44	400	807	475	P013	M58	146
	NANKU	N23133W082298	050/012	8.58	DES			P011	P05	43
	D246O	N22519W082401	060/009	9.03	DES			P008	P15	18
	UHA	N22560W082295	070/008	9.08	DES			M008	P22	5
	MUHA	N22593W082245	RAMP POSITION					M002	P25	0

NAVIGATION LOG

MAD(LEMD) 2000 FT TO HAV(MUHA) 210 FT DIV VRA(MUVR) 210 FT
ATC CLEARANCE

TAKE OFF TIME ..... LANDED .....
ELAP TIME 09.09
EST ARR TIME .....

Highly Recommended actual NAV (intent) data to report. Identifies intended flight.

AWY	MRA	IDENT	FREQ	FL	TRM	DIS	TM	MAC	ETA/RTA/ATA	AVWC TOGO	FUEL REQD /AVL
BARD1E	103	NVS	114.95	..	261	40	7		... ...	M012	50.4/...
BARD1E	109	TOC		..	281	46	9		... ...	M023	48.6/...
BARD1E	109	BARDI		..	281	49	7	772	... ...	M027	47.9/...
UM191	80	RIVRO		..	280	19	2	774	... ...	M034	47.6/...
UM191	89	ETP1		..	279	7	1	773	... ...	M035	47.5/...
UM191	89	VIS	113.10	..	280	47	7	773	... ...	M035	46.8/...
UM191	89	DIRMA		..	280	74	10	770	... ...	M032	45.5/...
UZ23	20	VEDEL		..	253	157	20	810	... ...	M001	43.6/...
UZ23	20	PIGOR		..	252	58	8	810	... ...	P005	42.9/...
UZ23	20	GUNTI		..	249	62	8	810	... ...	P004	42.1/...
264	20	ETP2		..	264	122	16	810	... ...	M012	40.6/...
263	20	3820N		..	263	122	16	810	... ...	M012	39.1/...

266	49	3630N		..	266	495	62	810	... ...	P009	33.4/...
272	20	E.ENT		..	272	184	23	810	... ...	P028	31.4/...
270	20	3440N		..	270	323	39	810	... ...	P028	28.0/...
274	20	ETP3		..	274	252	32	810	... ...	P006	25.3/...
272	20	3250N		..	272	268	34	810	... ...	P006	22.4/...
281	20	E.EXT		..	281	332	46	810	... ...	M026	18.6/...
278	20	3160N		..	278	185	25	810	... ...	M026	16.5/...
276	20	FIR		..	276	92	12	810	... ...	M017	15.5/...
273	20	PRUIT		..	273	256	35	810	... ...	M017	12.7/...
A637	20	NUTRE		..	253	122	15	810	... ...	P022	11.6/...
A637	20	ETP4		..	252	112	13	810	... ...	P027	10.5/...
A637	20	NOOGY		..	248	7	1	810	... ...	P027	10.4/...
A637	20	TOCCO		..	249	107	13	810	... ...	P026	9.4/...
A637	20	MILLE		..	248	98	12	810	... ...	P027	8.5/...
263	20	GUAVA		..	263	179	22	810	... ...	P026	6.8/...
266	20	ZQA	251.00	..	266	31	4	810	... ...	P025	6.5/...
249	20	PLUMA		..	249	39	5	807	... ...	P029	6.2/...
R628	20	MENDL		..	248	36	4	807	... ...	P026	5.8/...
R628	20	ZOLLA		..	248	26	4	807	... ...	P023	5.6/...
R628	20	TANIA		..	247	27	3	807	... ...	P021	5.3/...
NANKU2	26	FIR		..	260	7	1	807	... ...	P013	5.3/...
NANKU2	26	ETP5		..	259	15	2	807	... ...	P013	5.1/...
NANKU2	26	TOD		..	257	46	6	807	... ...	P013	4.7/...
NANKU2	26	NANKU		..	257	103	14		... ...	P011	4.4/...
NANKU2	32	D2460		..	207	25	5		... ...	P008	4.3/...
NANKU2	32	UHA	348.00	..	071	13	5		... ...	M008	4.2/...
NANKU2	32	MUHA		..	058	5	1		... ...	M002	4.1/...

(cont)
Highly
Recommended
actual NAV (intent)
data to report.
Identifies intended
flight.

ORIGIN TO TAKEOFF ALTERNATE

ALTERNATE LOG 1

AWY	MRA	IDENT	FREQ	FL	TRM	DIS	TM	MAC	ETA/RTA/ATA	TOGO	REQD /AVL
DCT		MUHA		CLB	000				... ...	P000	4.1/...
DCT	32	UHA	116.10	CLB	282	1			... ...	P000	4.1/...
J1	32	TOC		110	101	15	4	514	... ...	P007	2.5/...
J1	32	UZG	283.00	110	101	7	1	514	... ...	M001	2.4/...
J1	32	TOD		110	085	11	3	514	... ...	P001	2.3/...
J1	32	UVA	114.80	DES	085	22	6		... ...	P002	2.1/...
DCT		MUVR		DES	082	22	6		... ...	P000	1.9/...

FPCEP START OF WIND AND TEMPERATURE SUMMARY LEMD TO HAV

LEMD			VIS			VEDEL		
+FL020	220/6	P13	FL100	260/17	M4	FL100	333/25	M4
FL030	220/8	P11	FL140	272/20	M12	FL140	334/26	M11
FL050	220/13	P7	FL170	278/22	M17	FL230	336/30	M28
FL070	221/14	P2	FL190	283/25	M22	FL250	342/41	M33
FL090	221/16	M2	FL210	288/29	M26	FL270	347/57	M37
FL100	222/16	M4	FL230	291/32	M31	FL290	349/74	M42
FL110	223/18	M6	FL250	297/35	M36	FL310	350/82	M46
FL130	226/20	M10	FL270	302/37	M41	FL330	350/81	M50
FL140	227/22	M12	+FL290	307/40	M46	+FL350	347/75	M53
FL150	228/23	M14	FL310	310/40	M49	FL370	340/66	M53
			FL330	313/35	M51	FL390	332/57	M53
			FL350	311/30	M51	FL410	332/48	M54
			FL370	303/23	M50	FL450	331/32	M54
			FL390	292/17	M49			
			FL410	292/15	M50			

Highly
Recommended
meteorological
data to report.
actual wind @ alt.

ETP2		
FL100	341/44	P2
FL140	337/51	M5
FL280	348/69	M35
FL300	352/73	M40
FL310	353/74	M43
FL320	353/75	M46
FL330	354/76	M48
FL340	354/77	M51
+FL360	348/77	M55
FL380	342/78	M60
FL400	338/72	M61
FL430	332/60	M62

3820N		
FL100	341/44	P2
FL140	337/51	M5
FL280	348/69	M35
FL300	352/73	M40
FL310	353/74	M43
FL320	353/75	M46
FL330	354/76	M48
FL340	354/77	M51
+FL360	348/77	M55
FL380	342/78	M60
FL400	338/72	M61
FL430	332/60	M62

3630N		
FL100	054/18	P4
FL140	055/17	M4
FL280	092/22	M35
FL300	098/23	M40
FL310	096/24	M42
FL320	094/25	M45
FL330	092/26	M47
FL340	091/27	M50
+FL360	092/26	M54
FL380	093/24	M59
FL400	091/18	M61
FL430	055/5	M64

(cont)
Highly
Recommended
meteorological
data to report.
actual wind @ alt.

E.ENT		
FL100	159/14	P5
FL140	126/11	M4
FL300	063/20	M39
FL310	059/22	M41
FL320	056/24	M44
FL330	053/26	M46
FL340	051/28	M48
FL360	043/31	M53
+FL380	037/35	M57
FL400	032/34	M60
FL430	022/32	M64

3440N		
FL100	159/14	P5
FL140	126/11	M4
FL300	063/20	M39
FL310	059/22	M41
FL320	056/24	M44
FL330	053/26	M46
FL340	051/28	M48
FL360	043/31	M53
+FL380	037/35	M57
FL400	032/34	M60
FL430	022/32	M64

ETP3		
FL100	212/8	P5
FL140	212/10	M2
FL300	266/9	M36
FL310	271/10	M39
FL320	275/11	M41
FL330	278/12	M44
FL340	280/13	M46
FL360	280/14	M51
+FL380	280/15	M56
FL400	278/17	M60
FL430	273/19	M66

3250N		
FL100	212/8	P5
FL140	212/10	M2
FL300	266/9	M36
FL310	271/10	M39
FL320	275/11	M41
FL330	278/12	M44
FL340	280/13	M46
FL360	280/14	M51
+FL380	280/15	M56
FL400	278/17	M60
FL430	273/19	M66

E.EXT		
FL100	216/20	P4
FL140	215/26	M3
FL300	211/45	M36
FL310	211/47	M39
FL320	211/50	M42
FL330	212/52	M45
FL340	212/54	M47
FL360	211/54	M52
+FL380	210/54	M56
FL400	210/53	M60
FL430	211/50	M64

3160N		
FL100	216/20	P4
FL140	215/26	M3
FL300	211/45	M36
FL310	211/47	M39
FL320	211/50	M42
FL330	212/52	M45
FL340	212/54	M47
FL360	211/54	M52
+FL380	210/54	M56
FL400	210/53	M60
FL430	211/50	M64

FIR		
FL100	226/8	P4
FL140	228/7	M5
FL280	031/16	M34
FL300	033/20	M38
FL320	034/21	M42
FL340	034/22	M46
FL360	032/21	M50
FL380	030/20	M54
+FL400	031/19	M56
FL430	036/16	M60

PRUIT		
FL100	226/8	P4
FL140	228/7	M5
FL280	031/16	M34
FL300	033/20	M38
FL320	034/21	M42
FL340	034/22	M46
FL360	032/21	M50
FL380	030/20	M54
+FL400	031/19	M56
FL430	036/16	M60

NUTRE		
FL100	282/7	P5
FL140	319/10	M3
FL280	018/35	M33
FL300	021/38	M38
FL320	022/40	M42
FL340	023/41	M46
FL360	020/40	M50
FL380	017/39	M54
+FL400	017/37	M57
FL430	020/32	M62

NOOGY		
FL100	350/6	P7
FL140	357/12	M1
FL280	023/31	M32
FL300	028/32	M37
FL320	029/36	M42
FL340	030/39	M46
FL360	026/38	M50
FL380	022/38	M55
+FL400	021/36	M58
FL430	022/32	M63

MILLE		
FL100	060/12	P9
FL140	043/14	P1
FL280	044/26	M31
FL300	043/27	M36
FL320	042/31	M40
FL340	041/35	M45
FL360	041/35	M50
FL380	040/34	M55
+FL400	037/31	M59
FL430	027/24	M63

MENDL		
FL100	056/11	P9
FL140	050/12	P2
FL280	042/30	M29
FL300	041/34	M33
FL320	039/36	M38
FL340	037/38	M44
FL360	032/37	M48
FL380	026/36	M53
+FL400	018/34	M58
FL430	001/32	M64

```
 NANKU                    HAV
 FL060  066/13  P14       FL040  070/12  P17
 FL080  052/9   P11       FL060  065/12  P14
 FL100  029/7   P9        FL080  052/9   P11
 FL120  033/7   P5        FL100  026/6   P8
 FL140  036/8   P2        FL120  031/7   P5
 FL160  039/8   M2        FL140  035/8   P2
+FL180  042/9   M4        FL160  039/8   M2
 FL200  046/9   M9
 FL220  049/10  M13
 FL240  052/11  M18
 FL260  053/12  M23
 FL280  055/13  M28

FPCEP      END OF WIND AND TEMPERATURE SUMMARY LEMD TO HAV
           ------------------------------------------------
```

(cont)
Highly
Recommended
meteorological
data to report.
actual wind @ alt.

```
                         ETOPS INFORMATION

ELAP TIME ETP1  00.26 ETP2  01.35 ENTRY 03.16 ETP3  04.27 EXIT  05.47
ATD... ...ETA   .. ..       .. ..       .. ..       .. ..       .. ..
ATA... ...      .. ..       .. ..       .. ..       .. ..       .. ..
          ETP4  07.27 ETP5  08.38

EQT ALTNS MAD /LIS    LIS /SMA    SMA /BDA    BDA /NAS    NAS /HAV
ETOPS AREA ENTRY / EXIT. AIRPORTS OF REFERENCE: ENTRY SMA / EXIT BDA

                                                       FUEL  CRIT  2ENG
ETP1         MORA TRK  FL SAT  DST TIME IAS TAS G/S  REQD  FUEL  FUEL
N40380   MAD  109  94 100 M04  152 0.25 330 379 364  3470     0  3378
W006520  LIS   89 223 100 M04  154 0.25 330 379 369  3470     0  3378

ETP1  N40 W00 MAD   FL100 BELOW GMORA 109

FUEL REMAINING NO CONT 49977     FUEL REMAINING ALL CONT 52373

FUEL REQUIRED INCLUDES 00.0/00.0 PC ANTICING  0.000  PC DEG


                                                       FUEL  CRIT  2ENG
ETP2         MORA TRK  FL SAT  DST TIME IAS TAS G/S  REQD  FUEL  FUEL
N38316   LIS   31  88 100 M03  394 1.00 330 381 397  7810     0  7149
W017310  SMA   49 256 100 P00  376 1.00 330 384 379  7854     0  7187


FUEL REMAINING NO CONT 43070     FUEL REMAINING ALL CONT 45466

FUEL REQUIRED INCLUDES 00.0/00.0 PC ANTICING  0.000  PC DEG


                                                       FUEL  CRIT  2ENG
ETP3         MORA TRK  FL SAT  DST TIME IAS TAS G/S  REQD  FUEL  FUEL
N33079   SMA   49  77 100 P03  998 2.39 330 385 378 20249     0 17461
W044540  BDA   20 267 100 P04 1002 2.39 330 386 378 20336     0 17535


FUEL REMAINING NO CONT 27745     FUEL REMAINING ALL CONT 30141

FUEL REQUIRED INCLUDES 00.0/00.0 PC ANTICING  0.000  PC DEG


                                                       FUEL  CRIT  2ENG
ETP4         MORA TRK  FL SAT  DST TIME IAS TAS G/S  REQD  FUEL  FUEL
N27495   BDA   20  48 100 P05  403 1.02 330 387 388  7996     0  7009
W070228  NAS   20 246 100 P06  417 1.03 330 389 398  8101     0  7093
```

Highly
recommended
flight change data
to report.

FUEL REMAINING NO CONT 12965   FUEL REMAINING ALL CONT 15361

FUEL REQUIRED INCLUDES 00.0/00.0 PC ANTICING 0.000 PC DEG

(cont)
Highly recommended flight change data to report.

ETP5		MORA	TRK	FL	SAT	DST	TIME	IAS	TAS	G/S	FUEL REQD	CRIT FUEL	2ENG FUEL
N23559	NAS	20	64	100	P09	149	0.24	330	389	377	3104	0	3191
W079542	HAV	32	248	100	P08	150	0.24	330	389	381	3079	0	3172

FUEL REMAINING NO CONT 7601   FUEL REMAINING ALL CONT 9997

FUEL REQUIRED INCLUDES 00.0/00.0 PC ANTICING 0.000 PC DEG

ALTERNATE REQUIRED AVAILABILITY TIMES

ALTERNATE	FROM	TO
MAD	13.25	15.16
LIS	13.16	17.00
SMA	15.00	21.31
BDA	19.31	22.54
NAS	20.55	23.27
HAV	21.27	23.34

/ ETOPS ALTN /   (MAD N40283 W003337)
(LIS N38465 W009085)   (SMA N36584 W025103)
(BDA N32218 W064407)   (NAS N25023 W077280)
(HAV N22594 W082246)

OVERFLIGHT CHARGE COSTINGS
FPCEP   AEA/ 051/LEMD/MUHA   DATE: 26MAY08   MTOW: 233.00 TON

COUNTRY/AGENCY	FIR		DIST	FIR COST	CUR	USD	X/RATE
SPAIN	LECMZR	B	285 KM/GC	455.77	EUR	677.02	0.67
PORTUGAL	LPPCZR	B	CHARGED BY TOTAL DISTANCE				
PORTUGAL	LPPOZO	B	3054 KM/GC	1503.70	EUR	2233.66	0.67
UNITED STATES	KZNYZO	B	1127 NM	179.64	USD	179.64	1.00
BERMUDA	TXKFZR	B	474 KM	0.00	USD	0.00	1.00
UNITED STATES	KZNYZO	B	CHARGED BY TOTAL DISTANCE				
UNITED STATES	KZMAZO	B	CHARGED BY TOTAL DISTANCE				
UNITED STATES	KZMAZD	U	CHARGED BY TOTAL DISTANCE				
UNITED STATES	KZMAZR	U	791 NM	164.66	USD	164.66	1.00
CUBA	MUFHZR	B	383 KM	312.02	CUC	337.00	0.93

TOTAL COSTING FOR ROUTE: 1 =   3592.00 USD

NORMAL FLIGHT LEVEL SELECTION OVERRIDDEN BY DISPATCHER
BY USE OF PRF- KEYWORD ON CFP INPUT

+-+

Other critical data parameters requested are as follows:

[more TBD]

If there are conflicts in indentifying the requested information, please contact the US AIRE Program manager to discuss and coordinate the alternative parameters that can be applied.

APPENDIX VIII- AIRLINE PLANNING SYSTEM CHARACTERIZATION

Questions for Discussion with Airlines

This appendix contains a list of questions for airlines regarding flight planning:

1. What factors result in a flight plan using lower altitudes than can actually be flown? For example, when a flight flies at FL390 when the FPL shows FL360 as the requested altitude throughout the flight.
2. List the ATC route, boundary, and altitude constraints by Flight Information Regions that have a significant effect on your flights. For example, at the last AIRE demo, the PIARCO boundary and routes affected some of the AIRE flights. If future AIRE demos are both westbound and eastbound, and include other city pairs; what other constraints will be encountered? Are these constraints part of flight planning automation or are they applied manually? For example, if the rules for entering PIARCO were changed, what would need to change in the airline's flight planning programs.
    - In European domestic airspace
    - In Santa Maria airspace
    - In New York deep water oceanic airspace
    - In WATRS Plus oceanic airspace
    - In Downstream FIR airspace constraints (e.g., PIARCO)
3. How close to departure time can the flight plan trajectory be updated for En Route profile (route/altitude) changes?
4. How close to departure time can a flight plan be updated with a change to the fuel load?
5. Do the airlines think that more predictable route and altitude profiles will reduce their fuel load?
    - Would the airlines need to establish a consistent predictability before changing fuel load?
    - What magnitude of change is needed to affect pre-departure fuel load? For example, would a 200 kg savings be likely to reduce pre-departure fuel load?
6. Are there scheduling constraints based on the arrival airport that affect the route and altitude amendments (e.g., closing time and arrival competition that could lead to delays). Do the airlines use any airports where these types of constraints affect their planning?
7. During the last AIRE demo, were there airspace constraints over military areas that affected the routing? Were there any schedule uncertainties that if known would have mitigated inefficiency? How do the airlines get the military area schedules?
8. In the last AIRE demo, there was an option to file latitude and longitude with degrees and minutes? Does the airline's flight planning allow latitude and longitude with degrees and minutes?

9. Wind data source
   - Do any of the airlines use a commercial or public source of wind data. If public, which one?
   - What resolution/format (e.g., 6 hour update cycle, horizontal one degree, 50 millibar grids) is the wind data?
   - How frequently do the airlines receive updates to forecast wind products?
   - Do the aircraft receive in-flight weather updates from the airline?
   - Do any of the airlines use forecast wind products for flight planning?
     i. How accurate do the airlines perceive these products to be? In the last AIRE demo, there were some days where the actual winds were different from forecasted winds. For example, the actual and forecast en route flight times are close N out of M days.
     ii. Do the airlines evaluate the accuracy of the forecast wind product for their flights?
10. Convective weather and turbulence areas (current and forecast).
   - How do airlines flight plan for convective weather (and turbulence).
   - Do the airlines use forecast products?
   - How frequently do the airlines receive updates to these products?
   - Do the airlines find these products to be accurate?
11. During the last demo, did AEA require additional staffing resources for the AIRE demo?
12. Once an aircraft is in flight, how does the current work load affect the airline's ability to offer the aircraft route changes based on new weather/wind updates?
13. What limitations are the airlines facing today while flight planning?

Below is an approach to compare an "ideal" trajectory to an AIRE trajectory, and associated questions.

1. Define an "ideal" trajectory as a runway-to-runway trajectory (without any ATC constraints) that is "optimized" for minimum fuel burn given the airline's cost index [with forecast winds]. This would be an estimate for the overall maximum AIRE benefit goal.
   - Do the participating airlines have the capability to build ideal trajectories?
   - How different is an ideal trajectory (e.g., fuel burn) from actual flight trajectories that include ATC route and boundary constraints?
     - Can the fuel burn differences be allocated to climb, en route, and descent flight phases?
   - Do the participating airlines have the capability to rebuild some of the AIRE flight trajectories to compute a Minimum Fuel Burn Trajectory using forecast or actual winds? [either with cruise climbs or step climbs]
2. Is there a way to identify how altitude, speed, and route constraints contribute to the difference between an "optimal" versus actual flight plan?
3. Which factors can be mitigated in today's environment by coordination or collaboration?
4. What changes are needed to mitigate other factors (more accurate/frequent data, airspace redesign)?

APPENDIX IX- IMPACT MODELING:

AVIATION ENVIRONMENTAL DESIGN TOOL (AEDT)

For the AIRE demonstrations, the environmental metrics analysis is performed using portions of the Federal Aviation Administration's (FAA) Aviation Environmental Design Tool (AEDT), that incorporate proven methods of the Integrated Noise Model (INM) and the Emissions and Dispersion Modeling System (EDMS), as well as FAA's system for assessing Aviation's Global

Emissions (SAGE) and the Model for Assessing Global Exposure to the Noise of Transport Aircraft (MAGENTA).

The aircraft flight paths currently used during airport noise and emissions analysis are typically generated using technical guidance from standards documents such as the Society of Automotive Engineers (SAE) Aerospace Information Report (AIR)-18451 or the European Civil Aviation Conference (ECAC) Document 29. These documents describe methods for calculating aircraft flight paths using performance data and flight profiles supplied by aircraft manufacturers. The two main sources for these data accessible by the general public are the standard database from the FAA's INM, and EUROCONTROL's recently created Aircraft Noise and Performance (ANP) database. The two databases are consistent with each other and conform to SAE-AIR-1845 and ECAC Document 29 guidance. Flight profiles from the INM database are used directly when performing noise analyses with the INM and they are also used when modeling airport emissions using the current version of the FAA's EDMS.

The following sections identify the specific methodologies applied when using the AEDT to compute the key environmental metrics for the AIRE demonstrations. For many of the recent AEDT example case studies to demonstrate capabilities – NOx or CDA, go to and click on link: http://www.faa.gov/environment/models/aedt

FUEL BURN

AEDT Performance and Fuel Burn - Previously (for the NOx Round 2 Demonstration), the en-route (above 10,000 ft AFE) portions of the gate-to-gate flight trajectories were calculated by SAGE assuming a constant 3-degree (for jets) or 5-degree (for turboprops) glide slope between the cruise altitude and 10,000 ft AFE. For the AIRE analysis, the AEDT APM use follows the BADA Airline Procedure speed schedule within this region and the glide slope for each flight path segment is determined using BADA's Total Energy Model. Therefore the calculated glide slopes are a function of the specified speed schedule, the aircraft's performance characteristics, the aircraft's weight, and atmospheric conditions rather than being set to constant values. This change ensures that en-route portions of gate-to-gate flight trajectories more closely follow BADA specifications and therefore potentially improves the accuracy of fuel burn calculations for the descent portions of those trajectories.

The entire gate-to-gate trajectory for each flight is calculated using the AEDT APM, using SAE-AIR-1845 methods below 10,000 ft and BADA above. The AEDT APM ensures that there are no discontinuities in aircraft speed when the 1845 and BADA trajectories are merged together by adding acceleration or deceleration segments as needed or by changing target speeds. This ensures a continuous, flyable trajectory that is more realistic than two separate trajectories merged at a specific altitude.

The AEDT APM analysis sub-segments the terminal area trajectories in accordance with SAE-AIR-1845 and ECAC Doc 29, resulting in more points defining flight trajectories in the terminal area than were generated by the previous version of the performance module. It also produces more points defining the en-route (above 10,000 ft AFE) portion of the flight trajectories than SAGE did previously. These additional points provide a higher resolution description of the trajectories and ensure that aircraft weights are decremented more often due to the fuel burned over each flight path segment, resulting in more accurate flight trajectories, thrust levels, and fuel burn values.

With AEDT APM's strict use of SAE-AIR-1845 methods and more realistic descent portions of the trajectories, the weight values used on approach from 10,000 ft AFE to touchdown are also more accurate.

ENGINE EMISSIONS

AEDT Engine Emissions - Emissions modeling is conducted through various methods, depending on the specific pollutant. The following emissions were modeled for this demonstration:

> Carbon Dioxide (CO_2), Nitrogen Oxides (NO_x), Carbon Monoxide (CO), Hydrocarbons (HC), Water (H_2O), Sulfur Oxides (SO_x), non-Methane Hydrocarbons (NMHC), Volatile Organic Compounds (VOC), Methane (CH_4), Particulate Matter (PM) with an aerodynamic diameter of less than or equal to 10 μm (PM10), and PM with an aerodynamic diameter of less than or equal to 2.5 μm (PM2.5).

NOx, HC, and CO are modeled through the use of the Boeing Fuel Flow Method 2 (BFFM2). As described in Baughcum 1996 and ICAOf 2005, the method uses fuel flow generated from an external source, such as a performance model, to determine an emissions index, while accounting for engine installation effects and atmospheric conditions. At the heart of this method is the development of a log-log relationship between emissions indices (EI) and fuel flow data from the ICAO emissions databank [ICAOe 2005]. In contrast, CO_2, H_2O, and SO_x emissions are modeled based on fuel composition under a complete fuel combustion assumption. The resulting emissions indices were derived by Boeing [Baughcum 1996] and are presented as follows:

- CO_2: 3,155 g/kg
- H_2O: 1,237 g/kg
- SO_x: 0.8 g/kg (modeled as SO_2)

The remaining pollutants are modeled as follows:

- NMHC: Set equal to HC
- VOC: EDMS conversion factor based on type of flight
  - All (VOC = THC * 1.0)
  - Commercial (VOC = THC * 1.0947)
  - Military (VOC = THC * 1.1046)
  - General Aviation & Air Taxi, Piston (VOC = THC * 0.9649)
  - General Aviation & Air Taxi, Turbine (VOC = THC * 1.06631)
- CH_4: Not modeled; zero for now
- PM10: FAA first order approximation version 2.0 (FOA) [Wayson 2003]
- PM2.5: FAA first order approximation, equivalent to PM10

PM10 and PM2.5 are modeled identically, since all PM from aircraft have aerodynamic diameters less than 2.5 microns. In modeling these emissions, a simplified version of BFFM2 was used due to a current lack of standardized guidance regarding PM modeling. Fuel flow is adjusted for engine bleed and atmospheric effects as prescribed in BFFM2. However, the PM smoke number (SN) or derivative EI values from the FOA are not corrected, due to the aforementioned lack of standardized guidance. This was deemed acceptable, due to the overall uncertainties associated with using the SNs from the ICAO emissions databank. That is, the errors associated with correcting for atmospheric effects are likely to be much smaller than the errors associated with using SNs. The FOA is used to convert the SNs to EI values that are then used to plot EI versus fuel flow plots (i.e., rather than smoke number versus fuel flow). This method is consistent with the EI versus fuel flow plots used for the other pollutants (CO, HC, and NOx). Due to a lack of SN data for many engines in the ICAO databank, the following scheme was used:

- If only one data point is available, then use that value for all cases.
- If only two or three data points are available, then interpolate/extrapolate as appropriate.
- If no data points are available, then the output is “NULL” indicating that PM cannot be modeled for the engine. For modeling inventories at regional and global levels, the PM emissions are set to zero (0) for the “NULL” cases. In Round 1 of the NOx Demonstration, 13,239 out of a total 2,054,193 operations (<1%) were “NULL”; since aircraft PM was not reported, this has no impact on the NOx Demonstration.

In the future, the ICAO emissions databank will be preprocessed so that all empty entries for SN will be filled using various methods so that the aforementioned interpolation/extrapolation and "NULL" results will not occur. For this analysis, however, only the following emissions were reported: NOx, CO2, and H2O.

NOISE

AEDT Noise - FAA’s Integrated Noise Model (INM) is the basic noise engine integrated into AEDT and it follows fundamental acoustical computation methodology of numerous proven noise standards and analytical methods listed in References 1-13. The foundation for these noise calculations is the empirical noise database that provides aircraft source noise characteristics. The INM noise database is comprised of noise-power-distance data and aircraft spectral class data. The technical details about the generation of noise level and time-based metrics at a single observer, or at an evenly-spaced regular grid of observers, including the regular grid of observers that is used in the development of the recursively-subdivided irregular grid for noise contour analyses can be found in the References as well.

The noise computation process requires case information about airport conditions, aircraft types, operational parameters, geometry between the observer/flight-segment pair, and noise metric information.

For the AIRE arrival demos, the noise metrics being derived and computed are:

- Day Night Average Sound Level (DNL) contours - for cumulative airport operational noise (footprint) scenario comparisons. [when the data sample for number of flights is greater than 100 for a broad airport wide impact assessment]

- A-Weighted Sound Exposure Levels (SEL) at a series of grid points - for each individual approach track noise comparisons. [preferable when the data sample for number of flights is nominally 6 or more for a single event, operational changes assessment]